Revue Paleobiol., Genève (2000) Vol. spec. 8 : 45-52 ISSN 0253-6730

Lower Bathonian ammonites of Serra de la Creu (Tivissa, Catalan Basin, Spain)

Sixto Rafael FERNÁNDEZ-LÓPEZ[1]

Abstract

The study of ammonites of the Bajocian/Bathonian boundary from Serra de la Creu (Tivissa, province of Tarragona), a locality of the Catalan Basin, allows to recognize several bio- and chronostratigraphic units commonly missing in the Iberian Basin. The Parkinsoni Zone (Upper Bajocian) and the lowermost Zigzag Zone (Lower Bathonian) established for NW Europe areas can be identified in the Catalan and Iberian basins (Spain), although the ammonite fossil assemblages are composed by Submediterranean taxa.

Key words

Middle Jurassic, Ammonoids, taphonomy, biostratigraphy, chronostratigraphy, palaeobiogeography, Iberia.

INTRODUCTION

Ammonites of the Bajocian/Bathonian boundary are very scarce in the Iberian Basin, as a result of non-preservation in shallow water facies or gaps in the geological record. Several authors have mentioned the scarce occurrence of ammonites in the Iberian Basin during this chronostratigraphical interval (WESTERMANN, 1955; MENSINK, 1966; TINTANT & VIALLARD, 1970; BULARD, 1972; MARIN & TOULOUSE, 1972; HINKELBEIN, 1975; FERNÁNDEZ-LÓPEZ, 1976, 1985, 1997; FERNÁNDEZ-LÓPEZ *et al.*, 1978, 1985, 1996; FERNÁNDEZ-LÓPEZ & MOUTERDE, 1985; WILDE, 1988; FERNÁNDEZ-LÓPEZ & AURELL, 1988; THIERRY & WILDE, 1990). Lower Bathonian ammonites of this region, however, have never been figured. The ammonite succession discovered at the Serra de la Creu outcrop (Tivissa, province of Tarragona, Text-fig. 1), a locality of the Catalan Basin, allows to recognize several of these bio- and chronostratigraphic units commonly missing in the Iberian Basin.

The aim of this paper is to describe some Lower Bathonian ammonites from the Serra de la Creu (Tivissa) section, which until now were unknown from the Catalan and Iberian basins. The biochronological data obtained in this section are compared with those of the other European basins.

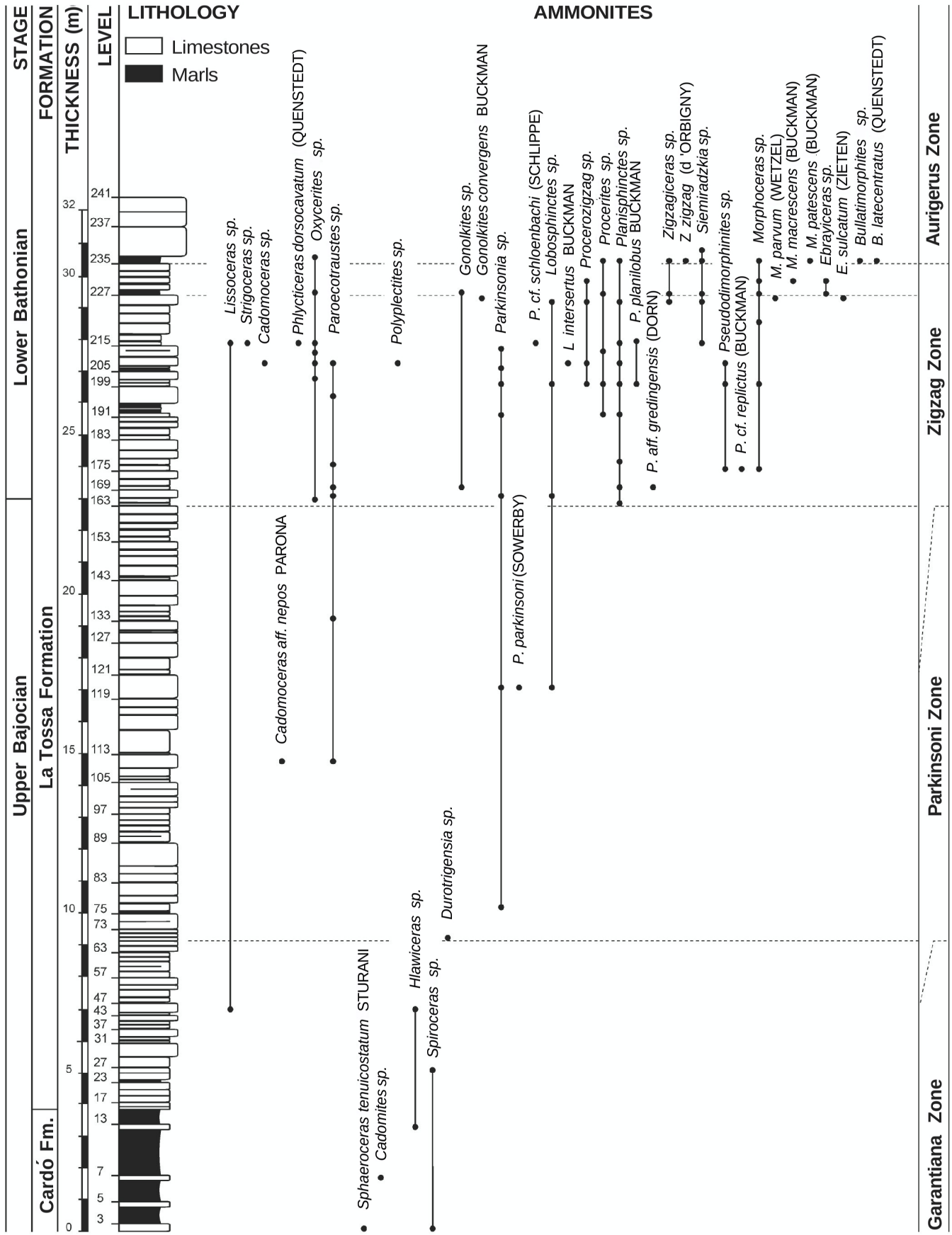
Text-fig. 1 Location map of the Serra de la Creu outcrop (CR, Tivissa, province of Tarragona, Catalan Basin) from the Iberian Peninsula.

AMMONITE TAPHONOMY

At the Tivissa area, the Upper Bajocian-Callovian limestones of the La Tossa Fm overlie Upper Bajocian marnes of the Cardo Fm (FERNÁNDEZ-LÓPEZ *et al.*, 1996, 1997, 1999). Beds of the Parkinsoni and Zigzag zones constitute the lowermost part of the La Tossa Formation in the Serra de la Creu outcrop (Text-fig. 2). At the type section of the La Tossa Fm, located in the Serra de la Creu outcrop (Tivissa), the lower part of this lithostratigrafic unit is composed by light yellow-brown, muddy limestones, regularly bedded, ranging in thickness from 10 to 120 cm, and alternating with marly intervals from 0 to 20 cm. These carbonate deposits are organized in shallowing-upwards sequences, of metric thickness, thickening upwards, which correspond to strati-

Depto. Paleontología (UCM) e Instituto de Geología Económica (CSIC-UCM), Facultad de Ciencias Geológicas, 28040-Madrid (Spain). E-mail: sixto@eucmax.sim.ucm.es.

Text-fig. 2: Biostratigraphical data of Upper Bajocian/Lower Bathonian ammonites in Serra de la Creu (Tivissa), type section of the La Tossa Fm.



graphic cycles of 5th order, resulting from changes in water turbulence and rate of sedimentation (FERNÁNDEZ-LÓPEZ, 1997). Fossils, especially ammonites, are scarce. Bivalves, terebratulid brachiopods, crinoid ossicles and belemnite guards occur.

The ammonites are commonly preserved as calcareous moulds of resedimented shells *(i.e.,* displaced on the sea-bottom, before their burial), partially infilled with mud, although some specimens show mouth-border or lappets intact (Plate I, fig. 7). Accumulated elements, showing no evidence of removal after laying on the sea-bottom, are very scarce or absent. Reelaborated, calcareous or phosphatic, concretionary internal moulds *(i.e.,* exhumed and displaced before their final burial) occur in some marly intervals (level CR227 in Text-fig. 2). However, the degree of taphonomic condensation *(i.e.,* mixture of fossils of different age or different chronostratigraphic units) reaches zero values in all cases. Ammonite mixed assemblages composed of specimens representing several biozones or biohorizons in a single bed have not been identified and the biostratigraphical completeness can reach 100%. Taphonic populations of type 3 *(i.e.* composed of polyspecific shells showing uni- or polymodal and asymmetric distribution of size-frequencies, with negative skew) are dominant, those of type 1 being not represented (FERNÁNDEZ-LÓPEZ, 1991, 1997, 2000). Shells of juvenile individuals are very scarce or absent, and shells of adult individuals are predominant. Biostratinomic processes of biodegradation-decomposition were intense. Before burial, ammonite shells commonly lose the soft-parts, the aptychi, the periostracum and the connecting rings. However, skeletal remains of encrusting organisms (such as serpulids, bryozoans or oysters) and biogenic borings are very scarce or absent. Complete concretionary internal moulds of the body chamber and phragmocone, indicative of low rates of sedimentation and accumulation, are scarce, and they are restricted to certain removal intervals (for example, level CR227 in Text-fig. 2). In contrast, compressed, partial internal moulds of body chambers *(i.e.,* hollow ammonites *sensu* FERNÁNDEZ-LÓPEZ, 1997, 2000), indicative of very rapid sedimentary infill and high rate of sedimentation, are abundant. Shells are normally filled by homogeneous sediment, similar to the sedimentary matrix. Hollow phragmocones *(i.e.,* shells without septa) are scarce, and shells were usually compressed by increasing sedimentary loading during diagenesis. The older septa can disappear by early dissolution, whilst the wall of the shell may still stand, giving rise to compressed elements showing discontinuous deformation by gravitational diagenetic compaction (Plate I, fig. 9). Fragmentary shells are common, but bearing no signs of rounding during resedimentation processes on the sea-bottom, due to the low turbulence near the water/sediment surface. Ammonites with their long axes parallel to bedding surface are dominant, and normally appear dispersed in the sediment, showing no pattern of imbricated or encased clustering.

These Last Bajocian/Early Bathonian ammonite shells represent ademic organisms and are interpreted as allochthonous elements having arrived at their present location by necroplanktic drift. The absence of taphonic populations of type 1, showing no signs of sorting by necroplanktic drift or transport, is indicative of allochthonous biogenic production of shells (FERNÁNDEZ-LÓPEZ, 1991, 1997). These Upper Bajocian/Lower Bathonian deposits are interpreted as having been deposited in an open sea, below wave base, in distal areas of the platform. The fine-grained nature of the mudstones suggests deposition in a low-turbulence setting. Currents were slight, but ammonite shells were reoriented on soft- to firmgrounds through resedimentation *(i.e.,* displacement on the sea-bottom, before their burial), and exceptionally by reelaboration (i.e., exhumation and displacement on the sea-bottom, before their final burial). These regional results allow to corroborate the development of a last phase of advanced shallowing of a deepening/shallowing cycle of 3rd order, in the Catalan and Iberian basins, during the Last Bajocian/Early Bathonian interval (FERNÁNDEZ-LÓPEZ, 1997).

AMMONITE BIO- AND CHRONOSTRATIGRAPHY

For the Upper Bajocian and Lower Bathonian, several biostratigraphic intervals have been distinguished in the lower part of the La Tossa Fm type section, taking into account the taxonomic data about the ammonites. The dimorphic status and abundance of specimens will be indicated by [M] and [m] macroconch and microconch forms; R, C, VC, scarce, common, very common respectively.

Upper Bajocian

In the Serra de la Creu (Tivissa) section, *Sphaeroceras tenuicostatum* STURANI has been identified in the last levels of the Cardo Fm (level CR2 in Text-fig. 2). The first bed of the La Tossa Fm (CR16) belongs to the Garantiana Zone (Upper Bajocian). This zone is characterized by scarce specimens of *Hlawiceras, Spiroceras* and *Sphaeroceras.* The most typical ammonites of the Parkinsoni Zone are *Durotrigensia* [M] and *Parkinsonia* [m]. A specimen of *P. parkinsoni* (SOWERBY) [m] has been identified in the level CR120 (Plate I, fig. 10). However, the scarcity of ammonites in the Parkinsoni Zone prevents recognition of subzones. Here the Parkinsoni Zone attains a maximum thickness of 14.0m (CR68-CR163) and is overlain by the Zigazag Zone, which attains a thickness of up to 7.0m.

Lower Bathonian

The stratigraphical interval CR164-CR240 belongs to the Lower Bathonian. Ammonites allow recognition of the Zigzag and Aurigerus zones, defined in the Submediterranean Province (CARIOU *et al.,* 1985). The lowermost zone of the Bathonian yields abundant perisphinctids and morphoceratids: *Lobosphinctes* [M] - *Planisphinctes* [m], *Procerozigzag* [M] - *Zigzagiceras* [m], *Procerites* [M] - *Siemiradzkia* [m], *Pseudodimorphinites* [M+m] and *Morphoceras* [M] - *Ebrayiceras* [m].

Two subzones can be recognized in the Zigzag Zone, respectively Parvum and Macrescens, the former being the better developed at the Tivissa area. The first (levels CR164- CR127) yields the earliest *Pseudodimorphinites* [M+m] and *Morphoceras* [M] - *Ebrayiceras* [m], proving the Submediterranean Parvum Subzone. The following taxa have been identified:

Lissoceras sp. [M] (R)
Strigoceras sp. [M] (R)
Cadomoceras sp. [m] (R)
Phlycticeras dorsocavatum (QUENSTEDT) [M] (R) (Plate I, fig. 8) (R)
Oxycerites sp. [M] (C)
Paroecotraustes sp. [m] (C)
Polyplectites sp. [m] (R)
Gonolkites convergens BUCKMAN [M] (R) (Plate I, fig. 1)
Parkinsonia cf. *schloenbachi* (SCHLIPPE) [m] (R)
Lobosphinctes intersertus BUCKMAN [M] (C) (Plate I, fig- 2)
Procerozigzag sp. [M] (R)
Procerites sp. [M] (C)
Planisphinctes planilobus BUCKMAN [m] (VC) (Plate I, fig- 3)
Planisphinctes aff. *gredingensis* (DORN) [m] (C) (Plate I, fig- 4)
Zigzagiceras sp. [m] (C)
Siemiradzkia sp. [m] (C)
Pseudodimorphinites cf. *replictus* (BUCKMAN) (R)
Morphoceras parvum (WETZEL) [M] (C) (Plate I, fig. 6)
Ebrayiceras sulcatum (ZIETEN) [m] (C)

The second subzone of the Zigzag Zone (levels CR128-CR235), characterized by *Morphoceras macrescens* (BUCKMAN) associated to *Procerozigzag* [M] - *Zigzagiceras* [m], belongs to the Submediterranean Macrescens Subzone.

Above CR235, the Aurigerus Zone is characterized by the first occurrence of *Bullatimorphites* [M], associated with *Morphoceras* [M] - *Ebrayiceras* [m] and the last specimens of *Procerozigzag* [M] - *Zigzagiceras* [m]. The following species have been identified:

Zigzagiceras zigzag (D'ORBIGNY) [m] (C) (Plate I, fig. 9)
Morphoceras patescens (BUCKMAN) [M] (C)
Bullatimorphites latecentratus (QUENSTEDT [M] (R)

PALAEOBIOGEOGRAPHICAL REMARKS

Separate zonal schemes have been established in Europe, for the Upper Bajocian and Lower Bathonian, due to faunal differences (Text-fig. 3). A northern European faunal region or Subboreal Province, from Britain to southern Germany, has been distinguished by several authors (WESTERMANN & CALLOMON, 1988; CALLOMON & COPE, 1995; PAGE, 1996; DIETZE & CHANDLER, 1997) giving careful consideration to the abundance of Parkinsonids. In contrast, Phyllo- and Lytoceratina characterizing the Mediterranean Province (CARIOU *et al.* 1985) are very common in the Subbetic Basin (SANDOVAL, 1983, 1990) and Majorca (ALVARO *et al.,* 1989). These taxonomic groups (Parkinsonids, Phyllo- and Lytoceratina) are very scarce in the so-called Sub-Mediterranean areas, such as Portugal, centre-west France, Nièvre, Macônnais and Jura (GALÁCZ, 1980; TORRENS, 1987; INNOCENTI *et al.* 1988; MANGOLD, 1990; RIOULT *et al.* 1997; MANGOLD & RIOULT, 1997; OLIVERO *et al.* 1997; GECZY & GALÁCZ, 1998).

In the Iberian Basin, Middle Jurassic Phylloceratina and Lytoceratina represent less than 1% of the whole of ammonoids (FERNÁNDEZ-LÓPEZ & MELÉNDEZ, 1996) and Lower Bathonian parkinsonids are scarce. A Sub-Mediterranean zonation can be recognized in the Basque-Cantabrian and Iberian basins (FERNÁNDEZ-LÓPEZ *et al.,* 1978, 1988; FERNÁNDEZ-LÓPEZ, 1985, 1988), and has also been applied to the Serra de la Creu (Tivissa) succession in the Catalan Basin. However, exceptional ammonoids recorded in the Iberian and Catalan basins at the uppermost Bajocian and Lower Bathonian correspond to adult individuals, arrived by necroplanktic drift from more open marine or oceanic areas.

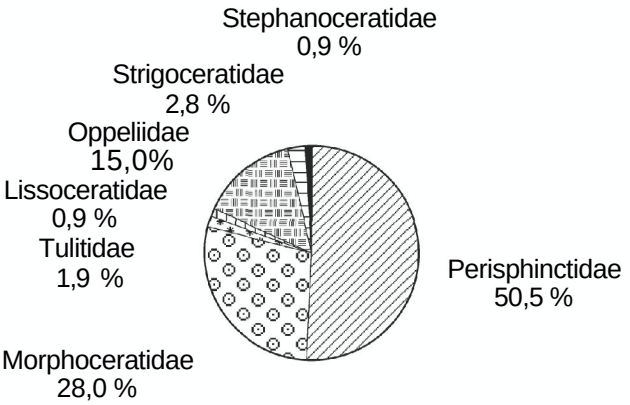
In the Serra de la Creu (Tivissa) section, the total number of the Lower Bathonian studied ammonites is up 100 (Text-fig. 4). Specimens of the family Perisphinctidae are common (50,5 %, in Tex-fig. 4). Zigzagiceratinae of the genera *Lobosphictes* [M] - *Planisphinctes* [m] and *Procerites* [M] - *Siemiradzkia* [m] are the most common ammonites in the Zigzag Zone. *Procerozigzag* [M] - *Zigzagiceras* [m] are fairly common. Among the Morphoceratidae (28,0 %), *Morphoceras* [M] - *Ebrayiceras* [m] are one of the most common ammonites in some levels of the Lower Bathonian. *Pseudodimorphinites* [M+m] occur. Parkinsoniinae of the genera *Gonolkites* [M] - *Parkinsonia* [m] are scarce. Representatives of the family Oppeliidae are scarce (15,0 %), but macroconch *{Oxycerites)* and microconch *{Paroecotraustes)* forms occur. Very scarce are the families Strigoceratidae (2,8 %), Tulitidae (1,9 %), Stephanoceratidae (0,9 %) and Lissoceratidae (0,9 %).

Consequently, the Parkinsoni Zone (Upper Bajocian) and the lowermost Ziazas Zone (Lower Bathonian) estab-

Text-fig. 3: Ammonite zones and subzones of the Uppermost Bajocian and Lower Bathonian in the so-called Subboreal (WESTERMANN & CALLOMON, 1988; CALLOMON & COPE, 1995), Sub-Mediterranean (MANGOLD, 1990; RIOULT *et al.* 1997; MANGOLD & RIOULT, 1997) and Mediterranean (SANDOVAL, 1983, 1990) provinces of Europe.

	Subboreal Province NW Europe: England, Lorraine, Alsace, Germany.		Submediterranean Province Centre-west France, Nièvre, Macônnais, Jura, Portugal, Iberian Basin		Mediterranean Province Betic Basin	
Lower Bathonian	Tenuiplicatus		Aurigerus	Tenuiplicatus	Zigzag	Postpollubrum
	Zigzag	Yeovilensis		Recinctus		Yeovilensis
		Macrescens	Zigzag	Macrescens		Macrescens
		Convergens		Parvum		Dimorphitiformis
Upper Bajocian	Parkinsoni	Bomfordi	Parkinsoni	Bomfordi	Parkinsoni	Dimorphus
		Truellei		Densicosta		Daubenyi
				Acris		

Text-fig. 4: Distribution of the percentage of the ammonite taxonomic groups (109 specimens) in the Lower Bathonian of the Serra de la Creu (Tivissa) section.



lished for NW Europe areas can be identified in the Catalan and Iberian basins, although the ammonite fossil assemblages are composed by Submediterranean taxa.

CONCLUSIONS

The Lower Bathonian at the Serra de la Creu (Tivissa) section, in the Catalan Basin, has a much better developed biostratigraphical succession previously barely recognised in the Iberian Basin. These Zigzag beds represent an expanded succession in relation to other well-known successions of the Iberian Basin. This section provides the best-known stratigraphical record of the Catalan and Iberian basins for the Lower Bathonian. However, its importance lies not in any value for palaeontological purposes. The relevance of this Lower Bathonian deposits lies in regional geological purposes.

ACKNOWLEDGEMENT

This work is a contribution to the projects PB92-0011 (DGICYT-CSIC) and PB96-0838 (DGESICYT - CSIC). The manuscript was closed 10th January, 2000.

REFERENCES

ÁLVARO, M., A. BARNOLAS, P. CABRA, M.J. COMAS-RENGIFO, S. FERNÁNDEZ-LÓPEZ, A. GOY, P. DEL OLMO, J. RAMIREZ DEL POZO, A. SIMÓ & S. URETA (1989) - El Jurásico de Mallorca (Islas Baleares). *Cuadernos de Geología Ibérica,* 13: 67-120.

BULARD, P,F. (1972) - Le Jurassique moyen et supérieur de la Chaîne Ibérique, sur la bordure du bassin de l'Ebre. Thèse Sci., Fac. Sc. (n° CNRS: A.O. 7095), Univ. Nice: 353 p.

CALLOMON, J.H. & J.C.W. COPE (1995) - The Jurassic Geology of Dorset. *In:* TAYLOR, P.D. (ed.): Field Geology of the British Jurassic. *Geological Society, London:* 51-104.

CARIOU, E., D. CONTINI, J.L. DOMMERGUES, R. ENAY,

J.R. GEYSSANT, C. MANGOLD & J. THIERRY (1985) - Biogéographie des Ammonites et évolution structurale de la Téthys au cours du Jurassique. *Bulletin de la Société géologique de France,* 1 (5): 679-697.

DIETZE, V. & R.B. CHANDLER (1997) - New Ammonites from the Zigzag Bed of Dorset. *Dorset Proceedings,* 119: 109-116.

FERNÁNDEZ-LÓPEZ, S. (1976) - El Bajociense en el extremo meridional de los Montes Universales (Teruel). I: Bioestratigrafía. II: Paleontología. Tesis de Licenciatura, Depto. Paleontología, Univ. Complutense Madrid: 104+227 p.

FERNÁNDEZ-LÓPEZ, S. (1985) - El Bajociense en la Cordillera Ibérica. Tesis Doctoral, Depto. Paleontología, Univ. Complutense Madrid: 850 p.

FERNÁNDEZ-LÓPEZ, S. (1988) - El Bajociense superior y Bathoniense inferior en Mataporquera (Santander). *Ciencias de la Tierra,* Geología, 11: 73-84.

FERNÁNDEZ-LÓPEZ, S. (1991) - Taphonomic concepts for a theoretical Biochronology. *Revista Española de Paleontología,* 6: 37-49.

FERNÁNDEZ-LÓPEZ, S. (1997) - Ammonites, taphonomic cycles and stratigraphic cycles in carbonate epicontinental platforms. *Cuadernos de Geología Ibérica,* 23: 95-136.

FERNÁNDEZ-LÓPEZ, S. (2000) - Ammonite taphocycles in carbonate epicontinental platforms. *In:* HALL, R.L. & P. L. SMITH (Eds.): Advances in Jurassic Research 2000. *GeoResearch Forum,* 6: 293-300.

FERNÁNDEZ-LÓPEZ, S. & M. AURELL (1988) - El Bajociense y Bathoniense de Ricla (Zaragoza). Características bioestratigráficas y sedimentológicas. *Ciencias de la Tierra,* Geología, 11: 251-264.

FERNÁNDEZ-LÓPEZ, S., M. AURELL, F. GARCÍA JORAL, J.J. GÓMEZ, J.J., M.H.P. HENRIQUES, G. MARTÍNEZ, G. MELÉNDEZ & L.C. SUÁREZ VEGA (1996) - El Jurásico Medio de la Cuenca Catalana: unidades litoestratigráficas y elementos paleogeográficos. *Revista Española Paleontología,* n° extra.: 122-139.

FERNÁNDEZ-LÓPEZ, S., M. AURELL, F. GARCÍA JORAL, J.J. GÓMEZ, M.H.P. HENRIQUES, G. MARTÍNEZ, G. MELÉNDEZ & L.C. SUÁREZ VEGA (1997) - El Jurásico Medio en la Plataforma de Tortosa (Cuenca Catalana): unidades litoestratigráficas, paleogeografía y ciclos ambientales. *Publicaciones del Seminario de Paleontología de Zaragoza,* 3: 177-213.

FERNÁNDEZ-LÓPEZ, S., M. AURELL, F. GARCÍA JORAL, J.J. GÓMEZ, M.H.P. HENRIQUES, G. MARTÍNEZ, G. MELÉNDEZ & L.C. SUÁREZ VEGA (1999) - La Plataforma de Tortosa (Cuenca Catalana) durante el Jurásico Medio: unidades litoestratigráficas, paleogeografía y ciclos ambientales. *Cuadernos de Geología Ibérica,* 24 (1998): 185-221.

FERNÁNDEZ-LÓPEZ, S., J.J. GÓMEZ & A. GOY (1985) - Le Dogger de Caudiel. Sédimentologie des carbonates développés sur un "monticule" de matériaux volcaniques. *Strata,* 2: 101-115.

Plate

Fig 1: *Gonolkites convergens* BUCKMAN. Incomplete phragmocone of immature macroconch. Right view. Specimen 1CR227/1. xl. Zigzag Zone. Parvum Subzone.

Fig 2: *Lobosphinctes intersertus* BUCKMAN. Incomplete phragmocone of immature macroconch. Left view. Specimen 1CR206/1. xl. Zigzag Zone. Parvum Subzone.

Fig 3: *Planisphinctes planilobus* BUCKMAN. Incomplete shell of immature microconch. Right view. Specimen 1CR202/1. xl. Zigzag Zone. Parvum Subzone.

Fig 4: *Planisphinctes* aff. *gredingensis* (DORN). Incomplete phragmocone of immature microconch. Left view. Specimen 1CR170/1. xl. Zigzag Zone. Parvum Subzone.

Fig 5: *Oxycerites* sp. Incomplete shell of immature macroconch. Left view. Specimen 1CR212/4. x2. Zigzag Zone. Parvum Subzone.

Fig 6: *Morphoceras parvum* (WETZEL). Complete shell of mature microconch. Right view. Specimen 1CR227/2. x 1. Zigzag Zone. Parvum Subzone.

Fig 7: *Cadomoceras* aff. *nepos* PARONA. Complete shell of mature microconch with lateral lappets. Left view. Specimen 1CR112/1. x2. Parkinsoni Zone.

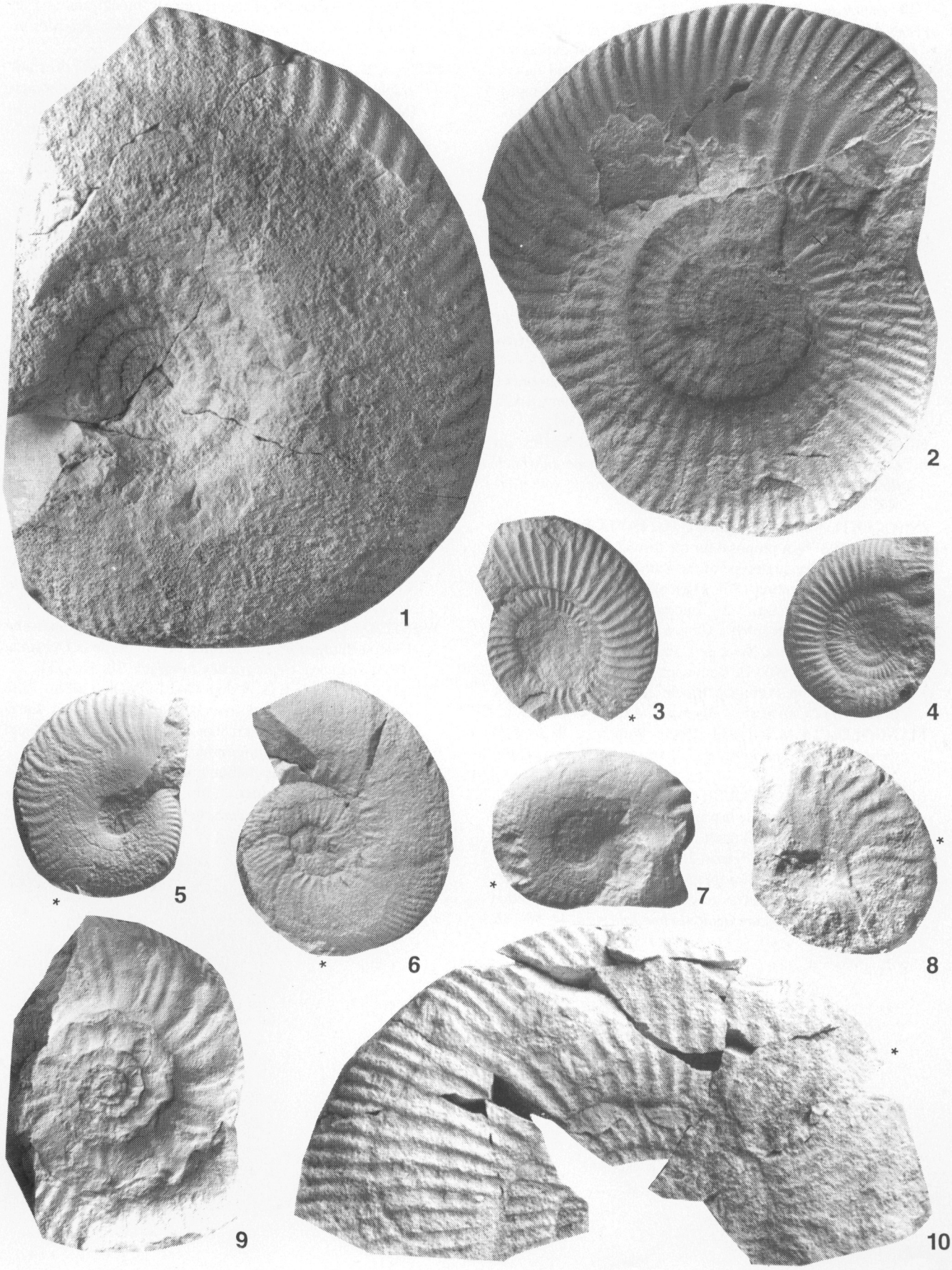
Fig 8: *Phlycticeras dorsocavatum* (QUENSTEDT). Incomplete shell of immature macroconch. Right view. Specimen 1CR216/2. xl. Zigzag Zone. Parvum Subzone.

Fig 9: *Zigzagiceras zigzag* (D'ORBIGNY). Incomplete shell of mature microconch. Right view. Specimen 1CR235/1. xl. Aurigerus Zone.

Fig 10: *Parkinsonia parkinsoni* (SOWERBY). Incomplete shell of immature microconch. Right view. Specimen 1CR120/1. xl. Parkinsoni Zone.

All the ammonites are in natural size, except for 5 and 7.
Asterisc indicates end of phragmocone.

Plate I



FERNÁNDEZ-LÓPEZ, S., J.J. GÓMEZ & S. URETA (1988) - Características de la plataforma carbonatada del Dogger en el sector meridional de la Sierra de La Demanda (Soria). *Ciencias de la Tierra,* Geología, 11: 167-195.

FERNÁNDEZ-LÓPEZ, S. & G. MELÉNDEZ (1996) - Phylloceratina ammonoids in the Iberian Basin during the Middle Jurassic: a model of biogeographical and taphonomic dispersal related to relative sea-level changes. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 120: 291-302.

FERNÁNDEZ-LÓPEZ, S., G. MELÉNDEZ & L.C. SUÁREZ VEGA (1978) - El Dogger y Malm en Moscardón (Teruel). Grupo Español de Mesozoico, Guía de excursiones: Jurásico Cordillera Ibérica, 6: 1-20.

FERNÁNDEZ-LÓPEZ, S. & R. MOUTERDE (1985) - Le Toarcien, l'Aalénien et le Bajocien dans le secteur de Tivenys: nouvelles données biostratigraphiques. *Strata,* 2: 71-82.

GALÁCZ, A. (1980) - Bajocian and Bathonian Ammonites of Gyenespuszta Bakony Mts., Hungary. *Geologica Hungarica,* 39: 1-228.

GÉCZY, B. & A. GALÁCZ (1998) - Bathonian ammonites from the classic Middle Jurassic locality of Villány, South Hungary. *Revue de Paléobiologie,* 17 (2): 479-511.

HINKELBEIN, K. (1975) - Stratigraphie und Fazies im Mitteljura der zentralen Iberischen Ketten. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen,* 148: 139-184.

INNOCENTI, M., C. MANGOLD, G. PAVIA & H.S. TORRENS (1988) - A proposal for the formal ratification of the basal boundary stratotype of the Bathonian Stage based on a Bas Auran section (S.E. France). *In:* ROCHA, R.B. & A.F. SOARES (Eds.) 2nd International Symposium on Jurassic Stratigraphy. Centro de Estratigrafía e Paleobiología Univ. Nova de Lisboa, 1: 333-346.

MANGOLD, C. (1990) - Le Bathonien du Cap Mondego (N de Figueira da Foz, Portugal). Biochronologie et corrélations. *Cahiers de l'Université Catholique de Lyon,* 4: 89-105.

MANGOLD, C. & M. RIOULT (1997) - Bathonien. *Bulletin du Centre de Recherches Elf Exploration Production, Mémoires,* 17: 55-62.

MARIN, Ph. & D. TOULOUSE (1972) - Le Jurassique moyen et supérieur du Nord de la province de Teruel (Espagne): un exemple du passage Dogger-Malm dans la région d'Ariño-Oliete. *Estudios Geológicos,* 28: 111-118.

MENSINK, H. (1966) - Stratigraphie und Paläogeographie des marinen Jura in den nordwestlichen Iberischen Ketten (Spanien). *Beihefte zum Geologischen Jahrbuch,* 44: 55-102.

OLIVERO, D., C. MANGOLD & G. PAVIA (1997) - La formation des Calcaires à *Zoophycos* du Verdon (Bathonien inférieur à Callovien moyen) des environs de Castellane (Alpes-de-Haute-Provence, France): biochronologie et lacunes. *Comptes Rendus de l'Académie des Sciences de Paris,* 324: 33-40.

PAGE, K.N. (1996) - Observations on the succession of stratigraphically useful ammonite faunas in the Bathonian (Middle Jurassic) of south-west England, and their correlation with a Sub-Mediterranean "Standard Zonation". Proceedings of the Ussher Society, 9: 45-53.

RIOULT, M., D. CONTINI, S. ELMI & J. GABILLY (1997) - Bajocien. *Bulletin du Centre de Recherches ElfExploration Production, Mémoires,* 17: 41-53.

SANDOVAL, J. (1983) - Bioestratigrafía y paleontología (Stephanocerataceae y Perisphinctaceae) del Bajocense y Bathonense en las Cordilleras Béticas. Doctoral Thesis, Univ. Granada: 613 p.

SANDOVAL, J. (1990) - A revision of the Bajocian divisions in the Subbetic Domain (southern Spain). *Memoire descrittive della Carta Geologica d'Italia,* 40: 141-162.

THIERRY, J. & S. WILDE (1990) - Bathonian-Callovian (Middle Jurassic) ammonite faunas of the Northwest Iberian Ranges: biostratigraphy and palaeobiogeography. *Cuadernos de Geología Ibérica,* 14: 143-156.

TINTANT, H. & P. VIALLARD (1970) - Le Jurassique moyen et supérieur de la Chaîne ibérique sud-occidentale aux confins des provinces de Teruel, Valencia et Cuenca. *Comptes Rendus de l'Académie des Sciences de Paris,* 6: 207-208.

TORRENS, H. (1987) - Ammonites and stratigraphy of the Bathonian rocks in the Digne-Barrême area (South-Eastern France, Dept. Alpes de Haute Provence). *Bolletino della Societa Paleontologica Italiana,* 26: 93-108.

WESTERMANN, G. E. G. (1955) - Biostratigraphische Untersuchungen im Jura südlich der Sierra de la Demanda (Nord Spanien). *Geologisches Jahrbuch,* 70: 519-534.

WESTERMANN, G.E.G. & J.H. CALLOMON (1988) - The Macrocephalitinae and associated Bathonian and Early Callovian (Jurassic) ammonoids of the Sula Islands and New Guinea. *Palaeontographica,* A203: 1-90.

WILDE, S. (1988) - Das Bathonium und Callovium der nordwest-iberischen Ketten (Jura, Spanien). *Bochumer Geologische und Geotechnische Arbeiten,* 31: 1-217.

Accepté juillet 2000